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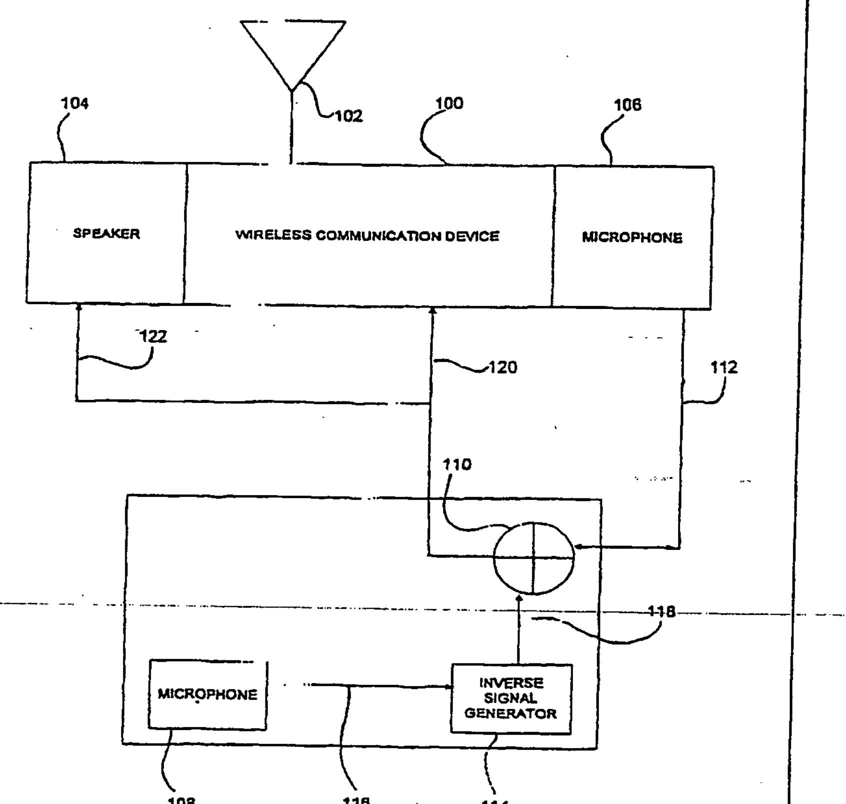
(54) Title: SYSTEM AND METHOD FOR AMBIENT NOISE CANCELLATION IN A WIRELESS COMMUNICATION DEVICE

(57) Abstract

Ambient noise is cancelled in a wireless communication device using a first microphone (106), a second microphone (108), an inverse signal generator (114), and a mixer (110). The first microphone (106) captures the voice of the user and the ambient noise. The second microphone (108) is positioned to effectively capture the ambient noise, but not the voice of the user. The inverse signal generator (114) receives the ambient noise signal from the second microphone (108) and outputs an inverted form thereof. The mixer (110) combines the signal from the first microphone (106) with the output of the inverse signal generator (114), thereby cancelling the ambient noise captured by the first microphone (106) by destructive interference. Thus, the output of the mixer (110) is a representation only of the voice of the user. The output of the mixer is also provided to the speaker or earpiece of the wireless communication device so that the user can self-regulate tone and level. When the user is listening to an incoming voice signal, the ambient noise is cancelled in the mixer by destructive interference, and the output of the mixer is provided to the speaker (104) or earpiece of the wireless communication device along with the incoming voice signal, without any ambient noise captured by the user's microphone.



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SYSTEM AND METHOD FOR AMBIENT NOISE CANCELLATION IN A WIRELESS COMMUNICATION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to noise cancellation in general, and more particularly, to ambient noise cancellation in a wireless communication device, such as a cordless telephone, a cellular telephone, a mobile radio, or the like.

2. Discussion of the Related Art

Generally speaking, ambient noise can be defined as any nonspecific but undesirable sound that interferes with the ability of a listener to hear desired sounds. In the case of a wireless communication device, the voice of the user and the voice of the caller are the desired sounds. Any other sounds present around the user of the wireless communication device (cordless telephone, cellular telephone, mobile radio, etc.) are considered to be ambient noise and are therefore undesired. Due largely to their portability and convenience, wireless communication devices are often used in locations that are rich in sources of ambient noise. Sources of ambient noise can be either natural, such as the sound of the wind blowing, or man-made such as the sound of motor vehicle traffic or overly loud conversations by other people. Locations where the user may encounter ambient noise while using a wireless communication device include shopping malls, sidewalks, urban parks, train stations, airports, public transportation

vehicles, and crowded rooms. Unfortunately, the ability to control the sources of ambient noise is usually beyond the authority of the user of the communication device, or the user is not readily able to move to a quieter location while using the communication device.

In most wireless communication devices, including mobile radios, some portion of the user's voice captured by the microphone or mouthpiece of the device is intentionally provided to the loudspeaker or earpiece of the device in order to offer the user a way to self-regulate the tone and level of his or her voice. Regrettably, any undesired ambient noise surrounding the user will also be captured by the wireless communication device and inadvertently provided to the user, along with the user's voice. The wireless communication device will also transmit to the listener, the user's voice and the ambient noise. In turn, the listener will hear both the user's voice and the ambient noise. Thus, ambient noise may tend to present a distraction for both the user and the listener by making it difficult to comfortably and clearly hear one another.

Accordingly, there is a need for an effective and inexpensive ambient noise cancellation system for a wireless communication device. A suitable ambient noise cancellation system should preferably be capable of substantially eliminating ambient noise, be small enough to fit within the microphone or mouthpiece section of the wireless communication device, and should preferably not cause an increase in the overall weight or cost of the device.

Basically, noise cancellation systems use various electro-acoustical methods to cause an undesired sound wave to be cancelled by mixing it with

an electronically generated sound wave having the same spatial geometry, amplitude and frequency as the undesired sound wave, except that the electronically generated sound wave is one-hundred-eighty degrees out of phase with the undesired sound wave. Thus, the electronically generated sound wave causes the undesired sound wave to be cancelled through a process of destructive interference. Effective application of active noise cancellation permits undisturbed perception of a desired sound wave with a maximum level of clarity and a minimum level of distortion.

Elaborate systems for noise cancellation are known to exist. For instance, U.S. Patent 5,224,168 to Martinez et al. discloses a system for the cancellation of noise and other compression waves using multi-channel noise cancellation techniques in conjunction with signal processing techniques. Their system comprises several microphones, a multi-channel signal processor, loudspeakers, and various filtering devices including neutralization filters. Essentially, the Martinez et al. system operates by generating a number of compression signals from compression waves detected by the microphones at a number of locations within a particular medium. The compression signals are processed by the multi-channel signal processor to produce complementary compression waves which are then directed towards the noise through the loudspeakers. Neutralization filters are utilized to compensate for the feedback which occurs when the loudspeakers and the microphones are situated in close proximity to one another.

In addition, U.S. Patent 5,140,640 to Graupe et al. discloses a self-adaptive noise cancellation system for use in a noisy environment, comprising a microphone and a stochastic identifier circuit. The

microphone captures noise signals from a noise source and directs the noise signals to the stochastic identifier circuit. The stochastic identifier circuit generates a set of stochastic parameters that characterize the noise signals from the source. The stochastic identifier circuit periodically updates these parameters to make the system adaptive and self-adjusting. A noise cancellation circuit generates an anti-noise signal or cancellation signal which is then directed to a loudspeaker positioned in proximity to the noise source. The cancellation signal combines with the noise from the source to substantially reduce the noise level.

Although each of the above two described systems disclose systems for noise cancellation, they rely upon intricate techniques or complicated equipment to function properly. Moreover, due to their size, relative complexity and numerous component parts, neither system in suitable for ambient noise cancellation in a wireless communication device.

SUMMARY OF THE INVENTION

The present invention is a simple and effective way to enhance the sound quality of wireless communication devices by canceling undesirable ambient noise surrounding the user of the device. The undesirable ambient noise is cancelled by destructive interference.

In accordance with one aspect, the present invention is directed to a method for cancelling an undesired audio frequency signal from a desired audio frequency signal in a wireless communication device, the wireless communication device comprising a first

audio frequency transducer, a second audio frequency transducer, an inverse signal generator, and a mixer. The method comprising the steps of capturing the desired audio frequency signal and the undesired audio frequency signal by the first audio frequency transducer and forming a first output signal thereof; capturing the undesired audio frequency signal by the second audio frequency transducer and forming a second output signal thereof; inputting the second output signal into the inverse signal generator; forming in the inverse signal generator a third output signal representing an inverse of the second output signal; inputting the first output signal into the mixer; inputting the third output signal into the mixer; combining in the mixer the first output signal and the third output signal; and outputting from the mixer a signal representing the first output signal minus the undesired audio frequency signal.

In accordance with another aspect, the present invention is directed to a system for cancelling an undesired audio frequency signal from a desired audio frequency signal in a wireless communication device. The system comprising a first sound sensor disposed to capture the desired audio frequency signal and the undesired audio frequency signal and produce a first electrical signal representative thereof; a second sound sensor disposed to capture the undesired audio frequency signal and produce a second electrical signal representative thereof; an inverse signal generator in connection with the second sound sensor, taking as input therefrom the second electrical signal and providing as output a third electrical signal representing the inverse of the second electrical signal; and a signal combiner in connection with the inverse signal generator and the

first sound sensor, the signal combiner taking as input the first electrical signal and the third electrical signal, and outputting therefrom the desired audio frequency signal with the undesired audio frequency signal cancelled.

In accordance with yet another aspect, the present invention is directed to a method for cancelling ambient noise surrounding the user of a wireless communication device, the wireless communication device comprising a first microphone, a second microphone, an inverse signal generator, and a mixer. The method comprising the steps of capturing the ambient noise by the first microphone and forming a first output signal thereof; capturing the ambient noise by the second microphone and forming a second output signal thereof; inputting the first output signal to the inverse signal generator; forming a third output in the inverse signal generator representing an inverse of the second output signal; inputting the first output signal to the mixer; inputting the third output to the mixer; combining the first output signal and the third output signal; and outputting from the mixer a signal devoid of the ambient noise captured by the first microphone.

In accordance with a further aspect, the present invention is directed to a system for cancelling background noise in a wireless communication device. The wireless communication device comprising first and second sound sensors, an inverse signal generator and a signal combiner; the first sound sensor being disposed to capture the voice of the user of the wireless communication device and background noise; the second sound sensor being disposed in a location to capture background noise; the first sound sensor being capable of producing a first electrical signal

representative of the voice of the user and the background noise; the second sound sensor being capable of producing a second electrical signal representative of the background noise; the first signal being provided to the signal combiner; the second signal being provided to the inverse signal generator; and the output from the inverse signal generator being provided to the signal combiner, wherein the output of the signal combiner is a third signal representative of the first signal minus the second signal.

In accordance with still a further aspect, the present invention is directed to an audio frequency waveform cancellation system. The audio frequency waveform cancellation system comprising a first audio frequency transducer for inputting a first audio frequency signal having a desired and an undesired component, and generating a first audio frequency waveform relating thereto; a second audio frequency transducer for inputting a second audio frequency signal related to the undesired component, and generating a second audio frequency waveform relating thereto; a waveform inverter receiving as input the second audio frequency waveform and generating as an output an inverse of the second audio frequency waveform; and an audio frequency combiner receiving as inputs the first audio frequency waveform and the output of the waveform inverter, and generating as an output the first audio frequency waveform with the undesired component cancelled by destructive interference.

Accordingly, the present invention is directed to a simple and effective system and method for cancelling ambient noise in wireless communication devices. The present invention is inexpensive and can be used with existing wireless communication devices

without adding additional weight or presenting any inconvenience to the user. The present invention is effective for cancelling ambient noise regardless of the source, and does not require maintenance or adjustment. Moreover, the ambient noise cancellation system of the present invention is easily adaptable to virtually any type of known wireless communication device, including but not limited to cellular telephones, cordless telephones or mobile radios, without regard to make and model, and without significant modification or degradation in the performance or efficiency of the wireless communication device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram representation of the ambient noise cancellation system of the present invention.

FIGURE 2 is a diagrammatic representation of a cordless or cellular telephone with the ambient noise cancellation system of the present invention.

FIGURE 3 is a diagrammatic representation of a mobile radio with the ambient noise cancellation system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a simple and effective way to enhance the sound quality of a wireless communication device by cancelling undesirable ambient noise surrounding the user of the device. The undesirable ambient noise is cancelled by destructive interference.

FIGURE 1 illustrates an exemplary embodiment for cancelling ambient noise in a wireless communication device 100 according to the present invention. The wireless communication device 100 is preferably a two-way, portable, electronic communication apparatus relying upon electronic circuitry to enable and control radio frequency (RF) transmission of an outgoing voice signal and reception of an incoming voice signal via an antenna 102. A loudspeaker or earpiece 104 is provided for the user to hear the incoming voice signal, and a first microphone 106 is provided to primarily capture or pick-up the voice of the user of the wireless communication device 100 for subsequent transmission. A second microphone 108 is provided to primarily capture or pick-up ambient noise surrounding the user of the wireless communication device 100. The ambient noise will preferably be subsequently cancelled. Either one or both of the first and second microphones 106, 108 may comprise any conventional type of sound pick-up device commonly used in wireless communication devices, such as, but not limited to, condenser or dynamic microphones, microphones comprising piezoelectric elements, or electrets.

The term ambient noise connotes any undesirable sound unrelated to the use of the wireless communication device. The voice of the user of the wireless communication device and the voice of the person speaking to the user of the wireless communication device are referred to as desired sounds or signals. However, any other type of sound that the user wants transmitted or received over the wireless communication device may also be deemed to be a desired sound. Both desired sounds and undesired sounds are

taken to exist in the audio frequency range, which is typically 20 Hz to 20 kHz.

The first microphone 106 is housed within the body of the wireless communication device 100 at a location to effectively capture or pick-up the voice of the user of the wireless communication device 100. However, in the course of ordinary use, the first microphone 106 will also inadvertently capture any ambient noise surrounding the user of the wireless communication device 100. The first microphone 106, converts the captured voice of the user and the inadvertently captured ambient noise into an electronic representation corresponding directly both to the user's voice and the noise. The electronic representation is then processed in either digital or analog form to create a first electrical signal. The first electrical signal is provided to a mixer, signal combiner or summing circuit 110 over connection 112 for subsequent cancellation of the inadvertently captured noise, further processing by the wireless communication device 100 and eventual transmission.

The second microphone 108 is provided at a location optimized to effectively capture or pick-up ambient noise surrounding the user, but not the user's voice itself. The second microphone 108, converts the captured ambient noise into an electronic representation of the noise surrounding the user of the wireless communication device 100. The electronic representation is then processed in either digital or analog form to create a second electrical signal that is fed to an inverse signal generator 114 over connection 116.

The inverse signal generator 114 produces as output, a third electrical signal identical in amplitude and phase to the ambient noise captured by

the second microphone 108, except in inverted form. The third electrical signal is sent to the mixer, signal combiner or summing circuit 110 over connection 118 for use in cancelling the ambient noise inadvertently captured along with user's voice by the first microphone 106.

The first electrical signal and the third electrical signal are electronically combined within the mixer, signal combiner or summing circuit 110, so as to cancel or subtract the noise component of the first electrical signal. Thus, the component of the first electrical signal corresponding to the ambient noise inadvertently captured or picked-up by the first microphone 106 is electronically cancelled by the third electrical signal, which is a representation of the noise captured by the second microphone 108 in inverted form.

Cancellation occurs by way of destructive interference which happens when the component of the first electrical signal representing the ambient noise is added to the third electrical signal, representing the inverse of the ambient noise. As a result, the noise component of the first electrical signal is cancelled. In algebraic terms, if the first electrical signal is represented as (v)+(n), where (v) is the voice of the user and (n) is the ambient noise captured by the first microphone 106, and the second electrical signal is represented as (n), which is the ambient noise captured by the second microphone 108, and if the third electrical signal, the output of the inverse signal generator which is an inverse of the second electrical signal, is represented as (-n), then the circuit 110 would perform the electrical equivalent of the algebraic calculation (v) + (n) + (-n) = (v), which is the voice signal of the user. Therefore, the output

of the circuit 110 is a clear version of the user's voice captured by the first microphone 106 without any of the inadvertently captured ambient noise also captured by the first microphone 106. The output of circuit 110 is provided as an outgoing voice signal to the wireless communication device 100 over connection 120 for further processing and eventual transmission. In addition, a portion of the output of circuit 110 is provided to the speaker 104 over connection 122 so that the user will be able to hear his or her own voice for purposes of self-regulation of tone and level.

Similarly, ambient noise surrounding the user will be cancelled by the present invention when the user is listening to an incoming voice signal received by the wireless communication device 100. In effect, when the user is listening and not speaking, the first microphone 106 captures only ambient noise, while the second microphone 108 captures ambient noise surrounding the user. In the manner described above, the first microphone 106 converts the captured ambient noise into an electronic representation corresponding to the noise. The electronic representation is then processed in digital or analog form to create a first electrical signal. The first electrical signal is provided to the circuit 110 over connection 112 for subsequent cancellation of the noise. The second microphone 108 and its associated circuitry converts the captured ambient noise into an electronic representation of the ambient noise surrounding the user of the wireless device 100. The representation of the ambient noise captured by the second microphone 108 is then processed in either digital or analog form to create a second electrical signal that is fed to the inverse signal generator 114 over connection 116.

As discussed above, the inverse signal generator 114 produces a third electrical signal identical in amplitude and phase to the ambient noise captured by the second microphone 108, except in inverted form. The third electrical signal is sent to the circuit 110 over connection 118 for eventual cancellation of the second electrical signal representing the ambient noise surrounding the user of the wireless communication device 100. Thus, the user will hear through the speaker 104 only the incoming voice signal without hearing any of the surrounding ambient noise.

The inverse signal generator 114 may be any integrated circuit (IC) adapted for outputting an inverted form of any waveform input thereto. It is conceivable that the inverse signal generator 114 and the mixer 110 may be incorporated into one single IC, adapted to subtract the noise signal from the second microphone 108 from the voice and noise signal from the first microphone 106, and then output therefrom an electrical signal representing only the user's voice signal captured by the first microphone 106.

FIGURE 2 is an exemplary embodiment of the present invention for a wireless communication device such as a cordless or cellular telephone 200. The cordless or cellular telephone 200 is provided with typical electronic circuitry to enable and control RF transmission of an outgoing voice signal and reception of an incoming voice signal, via an antenna 202. The cordless or cellular telephone 200 is also provided with a typical loudspeaker or earpiece 204 to allow the user to hear a voice signal, a keypad or control panel 206 to permit control and operation of the cordless or cellular telephone 200, and a typical alphanumeric display 208 to indicate the various functions and

settings of the cordless or cellular telephone 200, such as time of day, caller identification, battery condition, etc. A first microphone 210 is also provided to capture the voice of the user of the cordless or cellular telephone 200. However, in the course of ordinary use, the first microphone 210 will also inadvertently capture any ambient noise surrounding the user of the cordless or cellular telephone 200. A second microphone 212 is provided to capture primarily ambient noise surrounding the user without capturing the user's voice.

Either or both the first or user microphone 210 and the second microphone 212 may comprise a piezoelectric element. In an alternate embodiment, either or both first user microphone 210 or the second microphone 212 may comprise an electret. The user or first microphone 210 may be housed within the cordless or cellular telephone 200 on an end distant from the loudspeaker or earpiece 204. The second microphone 212 is also housed within the cordless or cellular telephone 200 at a location distant to the first microphone 210. For example, the second microphone 212 may be positioned at a distant corner of the cordless or cellular telephone 200, or on a rear face thereof. In fact, any location may be chosen for the second microphone 212 so long as the location chosen allows the second microphone 212 to capture primarily ambient noise surrounding the user, but not the user's voice.

The ambient noise captured by the second microphone 212 is processed and cancelled in the same manner as shown and discussed with respect to FIGURE 1. Hence, the signal from the second microphone 212 is forwarded to an inverse signal generator wherein an inverted form of the noise signal is created. The output of the inverse signal generator is sent to a

mixer, combiner or summing circuit within the telephone 200 where it is added to the signal captured by the user or first microphone 210. In the mixer, the signal representing the noise captured by the second microphone 212 is cancelled by destructive interference. Thus, the output of the mixer is only the user's voice, which was captured by the user's microphone 210, without the ambient noise that was inadvertently captured by the first microphone 210. Accordingly, the output of the mixer is a clear outgoing voice signal suitable for further processing and eventual transmission by the cordless or cellular telephone 200. In addition, a portion of the output of the mixer is provided to the speaker 204 so that the user will be able to hear his or her own voice for purposes of self-regulation of tone and level.

Similarly, ambient noise is cancelled when the user is listening to an incoming voice signal received by the cordless or cellular telephone 200 and not speaking. As discussed with respect to FIGURE 1, when the user is listening, the user microphone 210 captures only ambient noise while the second microphone 212 captures ambient noise surrounding the user. The user microphone 210 converts the captured ambient noise into an electronic representation corresponding to the noise. The electronic representation is then processed in digital or analog form to create a first electrical signal. The first electrical signal is provided to the mixer circuit for subsequent cancellation of the noise. The second microphone 212 and its associated circuitry converts the captured ambient noise into an electronic representation of the ambient noise surrounding the user of the telephone 200. The representation of the ambient noise is then processed in either digital or

analog form to create a second electrical signal that is fed to the inverse signal generator.

As discussed above, the inverse signal generator produces a third electrical signal identical in amplitude and phase to the ambient noise captured by the second microphone 212, except in inverted form. The third electrical signal is sent to the mixer for eventual cancellation of the second electrical signal representing the ambient noise. Thus, the user will hear through the speaker 204 only the incoming voice signal without hearing any of the surrounding ambient noise.

The inverse signal generator may be any integrated circuit (IC) adapted for outputting an inverted form of any waveform input thereto. It is conceivable that the inverse signal generator and the mixer may be incorporated into one single IC adapted to subtract the noise signal from the second microphone 212 from the voice and noise signal from the user microphone 210, and then output therefrom an electrical signal representing only the user's voice signal captured by the user microphone 210.

FIGURE 3 is an exemplary embodiment of the present invention for a wireless communication device such as a mobile radio 300. In this sense, a mobile radio is any two-way, portable, wireless communication device such as the type used by law enforcement personnel, firefighters, emergency service workers, and government or municipal services personnel. The mobile radio 300 is provided with typical electronic circuitry to enable and control RF transmission of an outgoing voice signal and reception of an incoming voice signal via an antenna 302. The mobile radio is also provided with a typical audio frequency loudspeaker 304 to allow the user to hear a voice signal, a keypad or control

panel 306 to permit operation of the mobile radio 300, and a handpiece 308. The handpiece 308 is in electrical connection with the mobile radio 300 by a cord or cable 316. Alternately, the handpiece 308 may be attached to or integral with the radio 300. The handpiece 308 houses a first microphone 310 which captures or picks-up the user's voice for eventual transmission by the mobile radio 300, and a transmit key or switch 312 which is actuated by the user when he or she desires to transmit a voice message. In the course of ordinary use however, when the transmit key or switch 312 is actuated, the microphone 310 will also inadvertently capture any ambient noise surrounding the user along with the user's voice. The mobile radio 300 is also provided with a second microphone 314 which captures or picks-up primarily ambient noise surrounding the user of the mobile radio 300, but not the user's voice. The placement of the second microphone 314 is similar to the placement in the device of Figure 2.

Either or both the first microphone 310 and the noise microphone 314 may comprise a piezoelectric element. In the alternative, either the first microphone 310 or the second microphone 314 may comprise an electret.

The ambient noise captured by the second microphone 314 is processed and cancelled in the same manner as shown and discussed with respect to FIGURE 1. Hence, the signal from the microphone 314 is forwarded to an inverse signal generator, wherein an inverted form of the noise signal is created. The output of the inverse signal generator is sent to a mixer where it is added to the signal captured or picked-up by the user microphone 310. The signal representing the noise captured by the microphone 314 is cancelled by

destructive interference in the mixer. Thus, the output of the mixer is only the user's voice, which was captured by the first microphone 310, without the ambient noise that was also inadvertently captured by the user microphone 310. Accordingly, the output of the mixer is a clear voice signal suitable for further processing and eventual transmission by the mobile radio 300. In addition, a portion of the output of the mixer is provided to the speaker 304 so that the user will be able to hear his or her own voice for purposes of self-regulation of tone and level.

Similarly, ambient noise is cancelled when the user is listening to an incoming voice signal received by the mobile radio 300. As discussed with respect to FIGURE 1, when the user is listening and not speaking, the user microphone 310 captures only ambient noise, while the second microphone 314 captures ambient noise surrounding the user. The user microphone 310 converts the captured ambient noise into an electronic representation corresponding to the noise. The electronic representation is then processed in digital or analog form to create a first electrical signal. The first electrical signal is provided to the mixer circuit for subsequent cancellation of the noise. The noise microphone 314 and its associated circuitry converts the captured ambient noise into an electronic representation of the ambient noise surrounding the user of the mobile radio 300. The representation of the ambient noise is then processed in either digital or analog form to create a second electrical signal that is fed to the inverse signal generator.

As discussed above, the inverse signal generator produces a third electrical signal identical in amplitude and phase to the ambient noise captured by the user microphone 310, except in inverted form. The

third electrical signal is sent to the mixer for eventual cancellation of the second electrical signal representing the ambient noise. Thus, the user will hear through the speaker 304 only the incoming voice signal without hearing any of the surrounding ambient noise.

The inverse signal generator may be any integrated circuit (IC) adapted for outputting an inverted form any waveform input thereto. It is conceivable that the inverse signal generator and the mixer may be incorporated into one single IC adapted to subtract the noise signal from second microphone 314 from the voice and noise signal from microphone 310, and then output therefrom an electrical signal representing only the user's voice signal from microphone 310.

Although the term microphone is used herein, it is conceivable that any type of audio frequency transducers or sound detector devices would serve to capture the user's voice or desired sound, and the ambient noise or undesired sound. Such audio frequency transducers or devices include, but are not limited to, condenser or dynamic microphones, piezoelectric microphones or electrets. Electrets can be used as microphones in much the same way as a permanent magnet is used in dynamic microphone. In an electret, the impinging sound waves cause a diaphragm attached to the electret to vibrate, which produces a fluctuating electric field. The fluctuating magnet fields produces an audio frequency voltage at the output terminals of the electret.

Although shown and described is what are believed to be the most practical and preferred embodiments, it is apparent that departures from specific methods and designs described and shown will

suggest themselves to those skilled in the art and may be used without departing from the spirit and scope of the invention. The present invention is not restricted to the particular constructions described and illustrated, but should be construed to cohere with all modifications that may fall within the scope of the appended claims.

CLAIMS

What is claimd is:

1. A method for cancelling an undesired audio frequency signal from a desired audio frequency signal in a wireless communication device, the wireless communication device comprising a first audio frequency transducer, a second audio frequency transducer, an inverse signal generator, and a mixer, the method comprising the steps of:

(a) capturing the desired audio frequency signal and the undesired audio frequency signal by the first audio frequency transducer and forming a first output signal thereof;

(b) capturing the undesired audio frequency signal by the second audio frequency transducer and forming a second output signal thereof;

(c) inputting the second output signal into the inverse signal generator;

(d) forming in the inverse signal generator a third output signal representing an inverse of the second output signal;

(e) inputting the first output signal into the mixer;

(f) inputting the third output signal into the mixer;

(g) combining in the mixer the first output signal and the third output signal; and

(h) outputting from the mixure a signal representing the first output signal minus the undesired audio frequency signal.

2. The method of claim 1, wherein the step (b) further comprises the step of locating the second audio

frequency transducer proximate the first audio frequency transducer.

3. The method of claim 1, wherein the step (b) further comprises the step of locating the second audio frequency transducer at a position distant from the first audio frequency transducer.

4. The method of claim 1, wherein the step (a) further comprises the step of capturing the desired audio frequency signal and the undesired audio frequency signal by an electret.

5. The method of claim 1, wherein the step (b) further comprises the step of capturing the undesired audio frequency signal by an electret.

6. The method of claim 1, wherein the step (a) further comprises the step of capturing the desired audio frequency signal and the undesired audio frequency signal by a piezoelectric element.

7. The method of claim 1, wherein the step (b) further comprises the step of capturing the undesired audio frequency signal by a piezoelectric element.

8. A system for cancelling an undesired audio frequency signal from a desired audio frequency signal in a wireless communication device, the system comprising:

a first sound sensor disposed to capture the desired audio frequency signal and the undesired audio frequency signal and produce a first electrical signal representative thereof;

a second sound sensor disposed to capture the undesired audio frequency signal and produce a second electrical signal representative thereof;

an inverse signal generator in connection with the second sound sensor, taking as input therefrom the second electrical signal and providing as output a third electrical signal representing the inverse of the second electrical signal; and

a signal combiner in connection with the inverse signal generator and the first sound sensor, the signal combiner taking as input the first electrical signal and the third electrical signal, and outputting therefrom the desired audio frequency signal with the undesired audio frequency signal cancelled.

9. The system of claim 8, wherein the first sound sensor comprises an electret.

10. The system of claim 8, wherein the second sound sensor comprises a piezoelectric element.

11. The system of claim 8, wherein the wireless communication device is a cellular telephone.

12. The system of claim 8, wherein the wireless communication device is a cordless telephone.

13. The system of claim 8, wherein the wireless communication device is a mobile radio.

14. A method for cancelling ambient noise surrounding the user of a wireless communication device, the method comprising the steps of:

(a) capturing the ambient noise by a first microphone and forming a first output signal thereof;

(b) capturing the ambient noise by a second microphone and forming a second output signal thereof;

(c) inputting the first output signal to a inverse signal generator;

(d) forming a third output in the inverse signal generator representing an inverse of the second output signal;

(e) inputting the first output signal to a mixer;

(f) inputting the third output to the mixer;

(g) combining the first output signal and the third output signal; and

(h) outputting from the mixer a signal devoid of the ambient noise captured by the first microphone.

15. The method of claim 14, wherein the step (b) further comprises the step of locating the second microphone proximate the first microphone.

16. The method of claim 14, wherein the step (b) further comprises the step of locating the second microphone at a position distant from the first microphone.

17. The method of claim 14, wherein the step (a) further comprises the step of capturing the ambient noise by an electret.

18. The method of claim 14, wherein the step (b) further comprises the step of capturing the ambient noise by an electret.

19. The method of claim 14, wherein the step (a) further comprises the step of capturing the ambient noise by a piezoelectric microphone.

20. The method of claim 14, wherein the step (b) further comprises the step of capturing the ambient noise by a piezoelectric microphone.

21. A system for cancelling background noise in a wireless communication device comprising:

first and second sound sensors, an inverse signal generator and a signal combiner;

the first sound sensor being disposed to capture the voice of the user of the wireless communication device and background noise;

the second sound sensor disposed in a location to capture background noise;

the first sound sensor being capable of producing a first electrical signal representative of the voice of the user and the background noise;

the second sound sensor being capable of producing a second electrical signal representative of the background noise;

the first signal being provided to the signal combiner; the second signal being provided to the inverse signal generator; and

the output from the inverse signal generator being provided to the signal combiner, wherein the output of the signal combiner is a third signal representative of the first signal minus the second signal.

22. The system of claim 21, wherein the second sound sensor is disposed proximate the first sound sensor.

23. The system of claim 21, wherein the second sound sensor is disposed at a location distant from the first sound sensor.

24. The system of claim 21, wherein the first sensor is an electret.

25. The system of claim 21, wherein the second sensor is an electret.

26. The system of claim 21, wherein the first sensor comprises a piezoelectric element.

27. The system of claim 21, wherein the second sensor is a piezoelectric element.

28. An audio frequency waveform cancellation system, comprising:

a first audio frequency transducer for inputting a first audio frequency signal having a desired and an undesired component, and generating a first audio frequency waveform relating thereto;

a second audio frequency transducer for inputting a second audio frequency signal related to the undesired component, and generating a second audio frequency waveform relating thereto;

a waveform inverter receiving as input the second audio frequency waveform and generating as an output an inverse of the second audio frequency waveform; and

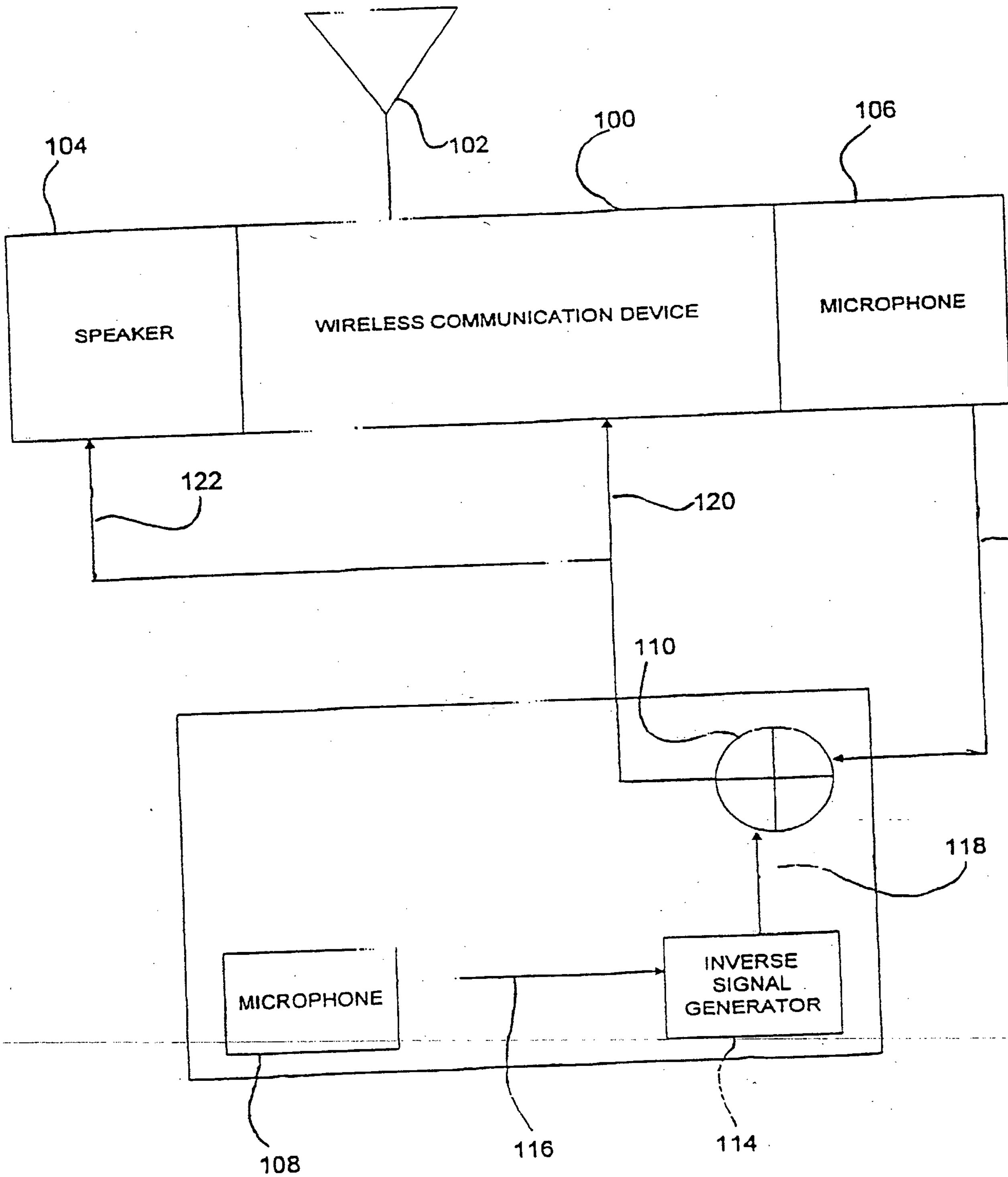
an audio frequency combiner receiving as inputs the first audio frequency waveform and the output of the waveform inverter, and generating as an output the first audio frequency waveform with the

undesired component cancelled by destructive interference.

29. The system of claim 28, wherein the desired and the undesired components comprise voice and noise, respectively.

30. The system of claim 28, wherein the second audio frequency signal related to the undesired component comprises noise.

FIGURE 1


104
102
100
106
SPEAKER
WIRELESS COMMUNICATION DEVICE
MICROPHONE
122
120
112
110
118
MICROPHONE
INVERSE
SIGNAL
GENERATOR
108
116
114

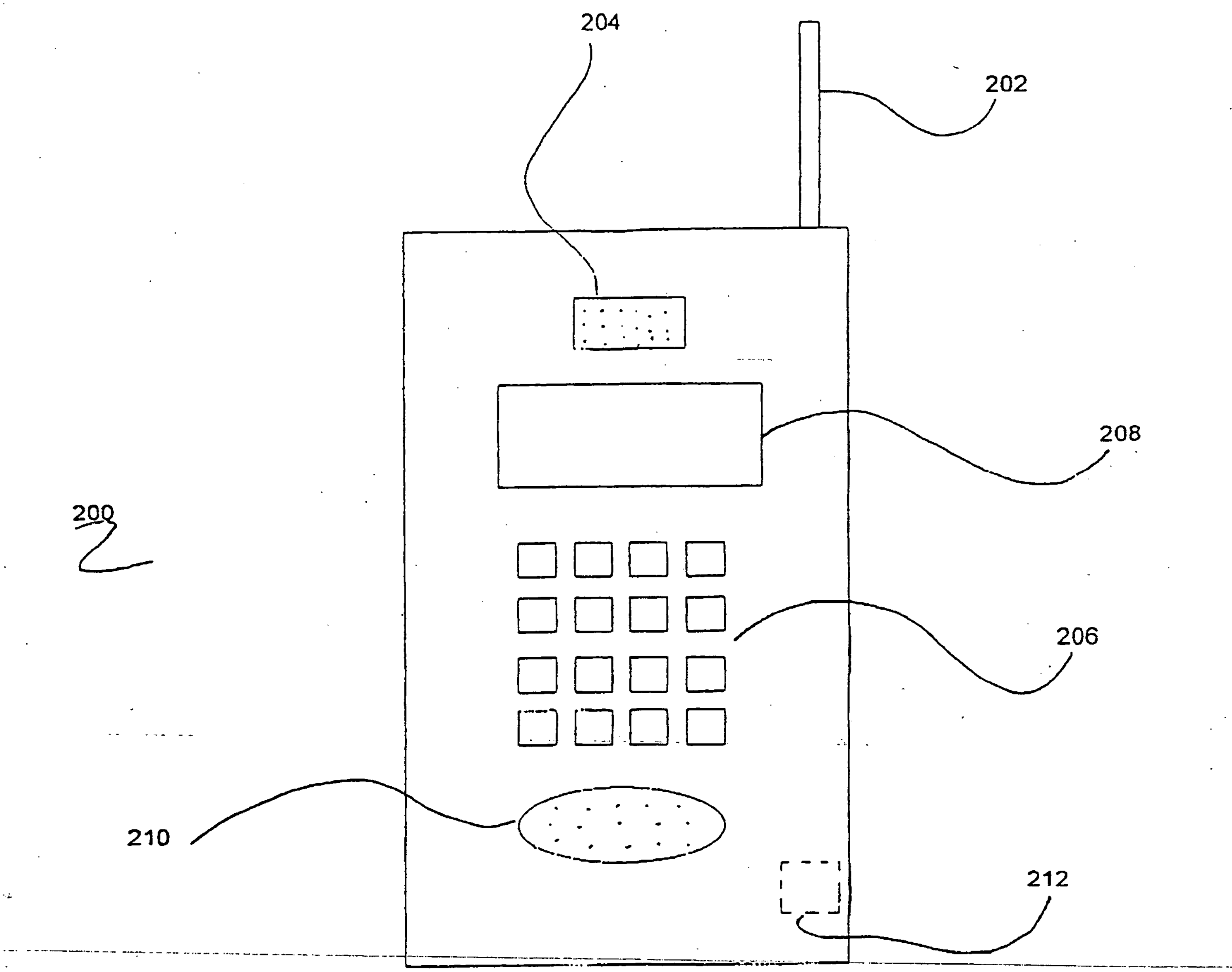


FIGURE 2

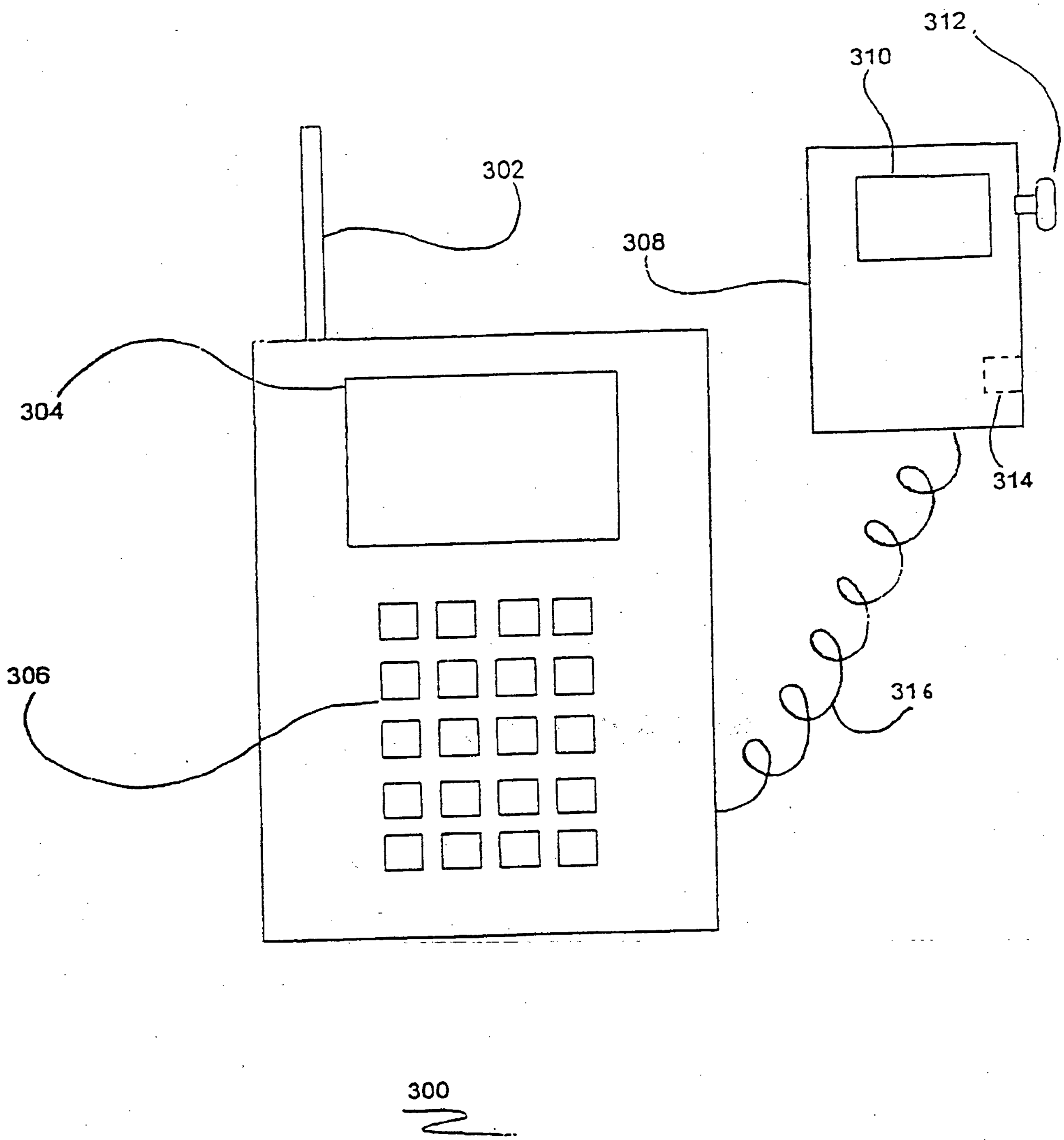


FIGURE 3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US00/06464

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :A61F 11/06
US CL :381/71.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 381/71.1, 71.6, 71.8

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,673,325 A (ANDREA et al) 30 September 1997, figs. 2 and 8.	1-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date		
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 MAY 2000	01 JUN 2000

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